

# Unit 4 Topic 3: Periodicity

## CDO IB Chemistry SL/HL

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### Assessment Statements

#### 1. The Periodic Table

- Describe the arrangement of the periodic table in order of increasing atomic number
- Distinguish between group and period
- Apply the relationship of electron arrangement and the position on the PT
- Apply the relationship between the number of electrons and the highest occupied energy level for an element and its position on the PT

#### 2. Physical Properties

- Define the terms first ionization energy and electronegativity
- Describe and explain the trends of ionization energy, atomic radii, ionic radii and electronegativity
- Describe the relative electronegativity values of two or more elements based on their positions on the periodic table

#### III. Chemical Properties

- Discuss the similarities and differences in chemical properties in the same group
- Discuss the changes in nature from ionic to covalent and from basic to acidic of the oxides of period 3

## Structure of the Periodic Table

- Periods –
  - Groups –
  - Group # -
- 
- Example: How many outer shell electrons does P have?

## Identifying Physical Properties

- Physical properties depend ultimately on

## Periodic trends

### Effective Nuclear Charge

- Nuclear charge –
  - Outer electrons –
- 
- Effective nuclear charge –

### Determining Effective Nuclear Charge

- Equation
  - $Z_{\text{eff}} =$
- Trends
  - Increases
  - Stays

### Periodic Trends – The Basic Idea

- Force of attraction of electrons to the nucleus depends on 2 factors –
- 
- Across a period –
- 
- 
- 
- 
- 
- 
- 
- 
- 
- 
- Down a group –

## Atomic Radius

Atomic radius is determined by two factors.

1.

2.

## Atomic Radius in a Group

- Atomic size generally.
- Electrons are added to higher principal energy levels

## Atomic Radius in a Period

- As you proceed across a period,
- The number of energy levels. . .
- The effective

## Example 1

Choose the larger atom in each pair:

- Na or Si
- P or Sb
- Al or Cl
- Al or In

- **Ionic Radius**

- Ionic Radius trend is essentially the same as the atomic radius, but now we are talking about the ions (cation or anion)
  - If positively charged the radius
  - If negatively charged the radius
  - When substances have the same number of

**Example 2**

Choose the larger particle in each pair

- Na or  $\text{Na}^+$
- $\text{F}^-$  or F
- $\text{Al}^{3+}$  or Al

**Example 3**

Predict which of the following substances has the largest radius:  $\text{P}^{3-}$ ,  $\text{S}^{2-}$ ,  $\text{Cl}^-$ , Ar,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ .

**IONIZATION ENERGY**

- Ionization energy,  $E_i$ : minimum energy required to
- Factor that affect IE –

#### Example 4

Choose the atom with the larger ionization energy in each pair

- B or C
- O or S
- Cl or I

#### Electronegativity

- Electronegativity is the tendency
- Electronegativity is used to predict the
- Electronegativity is expressed in a qualitative measurement called
- The scale assigns the highest value to

#### Electronegativity Trends

Going across a period,

- Metals have low

Electronegativity

- The ability of an atom to attract electrons

#### Example 6

Predict the order of increasing electronegativity in each of the following groups of elements.

- C, N, O
- S, Se, O

- **Melting Points**

- Melting point –

- **Melting points of the Group I Elements**

- Melting point
- Reason for the trend
  - Metallic Bonding –

- **Melting Point of the Group VII Halogens**

- Melting Point
- Reasoning
  - Halogens are diatomic –
  - The attractive forces

- **Melting points Across Period 3**

- Determine the trend by breaking into 4 main sections
  - Metals –
  - Giant Covalent –
  - Molecular Covalent –
  - Atoms –

## Chemical properties

- **Reactivity of the Noble Gases**

- Basic properties

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- **Reactivity of the Group I Alkali Metals**

- Too reactive
  - Form a single cation ( $M^+$ )
  - Have very
  - Reactivity
  - Conduct

- **Reaction of the Alkali Metals with Water**

- React with water to form –
  - Examples
    - $\text{Li(s)} + \text{H}_2\text{O(l)} \rightarrow$
    - $\text{Na(s)} + \text{H}_2\text{O(l)} \rightarrow$
    - $\text{K(s)} + \text{H}_2\text{O(l)} \rightarrow$

- **Halogens**

- Exist as
- They are
- Gradually
- They are

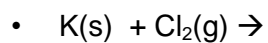
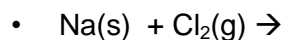
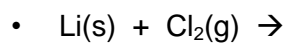
- **Halogens Vs. Halides**

- Halogens –
- Halide -

- **Group I Metals Reactivity with Halogens**

- Alkali Metals react with halogens to form their salts (called halides) –

- Examples

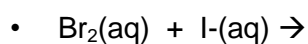
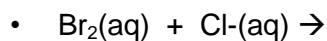
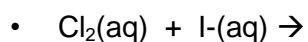
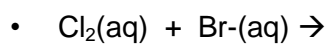


- **Halogen reacting with a Halide**

- The ability to react with
- Electron attraction



- Halogen Halide Reaction Examples



- **Bonding of the Period 3 Oxides**

- Ionic compounds exist between

- Ex:

- Molecular covalent compounds –

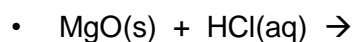
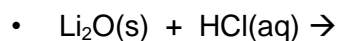
- Ex:

- Giant Covalent –

- **Acid Base Character of the Period 3 Oxides - Basic**

- Basic Oxides

- Example:



- **Acid Base Character of the Period 3 Oxides - Acidic**
  - Non metal oxides
  - Example
  - $\text{P}_4\text{O}_{10}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow$
  - $\text{SO}_3(\text{l}) + \text{H}_2\text{O}(\text{l}) \rightarrow$
- **Acid Base Character of the Period 3 Oxides - Amphoteric**
  - Amphoteric –
  - Aluminum oxide –
  - Amphoteric examples
  - Acid:  $\text{Al}_2\text{O}_3(\text{s}) + \text{OH}^- \rightarrow$
  - Base:  $\text{Al}_2\text{O}_3(\text{s}) + \text{H}_2\text{SO}_4 \rightarrow$

1. Rank the following elements by increasing atomic radius: carbon, aluminum, oxygen, potassium.
2. Rank the following elements by increasing electronegativity: sulfur, oxygen, neon, aluminum.
3. Why does fluorine have a higher ionization energy than iodine?
4. Indicate whether the following properties increase or decrease from left to right across the periodic table.
  - a. atomic radius (excluding noble gases)
  - b. first ionization energy
  - c. electronegativity
5. What trend in atomic radius occurs down a group on the periodic table? What causes this trend?
6. What trend in ionization energy occurs across a period on the periodic table? What causes this trend?
7. Circle the atom in each pair that has the largest atomic radius.
  - d. Al or B
  - e. Na or Al
  - f. S or O
  - g. O or F
  - h. Br or Cl
  - i. Mg or Ca
8. Circle the atom in each pair that has the greater ionization energy.
  - j. Li or Be
  - k. Ca or Ba
  - l. Na or K
  - m. P or Ar
  - n. Cl or Si
  - o. Li or K
9. Define electronegativity.
10. Circle the atom in each pair that has the greater electronegativity.
  - p. Ca or Ga
  - q. Br or As
  - r. Li or O
  - s. Ba or Sr
  - t. Cl or S
  - u. O or S

Ionic Bond	between a Metal and Non-Metal	(M + NM)
Covalent Bond	between a Non-Metal and Non-Metal	(NM + NM)
Metallic Bond	between a Metal and Metal	(M+ M)

Determine if the elements in the following compounds are metals or non-metals. Describe the type of bonding that occurs in the compound.

Compound	Element 1 (metal or non-metal?)	Element 2 (metal or non-metal?)	Bond Type
NO <sub>2</sub>	N = non-metal	O = non-metal	covalent
NaCl			
SO <sub>2</sub>			
PO <sub>4</sub> <sup>3-</sup>			
MgBr <sub>2</sub>			
H <sub>2</sub> O			
K <sub>2</sub> O			
Cu-Zn alloy			
O <sub>2</sub>			
CuCl <sub>2</sub>			
NO <sub>2</sub> <sup>-</sup>			
TiO <sub>2</sub>			
Au-Ag mixture			
Fe <sub>2</sub> O <sub>3</sub>			
C <sub>6</sub> H <sub>12</sub> O <sub>22</sub>			

1. Write balance equations for each of the following reactions:
  - a. Rubidium and water
  - b. Potassium and water
  - c. Chlorine solution with potassium bromide solution (Bromide ion)
  - d. Sodium oxide with water
  - e. Sulfur trioxide with water
  
2. Arrange the following in order of increasing melting point (lowest 1<sup>st</sup>)

a. Cl <sub>2</sub>	Na	F <sub>2</sub>	K	
b. Si	Mg	Cl <sub>2</sub>	Ar	Ne
c. Na <sub>2</sub> O	P <sub>4</sub> O <sub>10</sub>	O <sub>2</sub>		
  
3. State whether an acidic or alkaline (basic) solution will be formed when each of the following is dissolved/reacted in water
  - a. SO<sub>3</sub>
  - b. MgO
  - c. Na